

25.

Respiratory Behavior in Fishes Not Especially Modified for Breathing Air Under Conditions of Depleted Oxygen.

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(Plate I).

Among fishes living in environments which are usually or periodically depleted of dissolved oxygen are many with specialized respiratory accessories which permit them to make use of atmospheric oxygen direct or indirectly. Fishes without equipment capable of coping with situations of depleted oxygen must perish when confronted with them unless escape is possible. When simple escape by flight is impossible, at least certain of such fishes will make attempts to seek out methods of survival which are certainly not part of the normal scheme of their activities. Two cases, indicative of such efforts at survival, seem to be rather suggestive of a point of approach to the whole problem of fish behavior in adjusting to changing environmental conditions.

One case involved a large female *Lebistes reticulatus* (Peters) in the laboratory of the New York Aquarium which was being used for some experimental work involving other matters but which incidentally concerned activities under restricted oxygen supply. In the course of this experiment small measured blocks were floated on the surface as a means of restricting gaseous interchange between the air and water. In the one referred to, the surface was nearly covered with these floats with one *Lebistes* in the water below. Following its natural response to rise to the surface and take advantage of the greater amount of oxygen near the surface film, which by virtue of peculiarly specialized mouths the Microcyprini are able to do efficiently, it found normal behavior under such conditions impossible because of the crowded floating blocks. After some little effort it managed to wriggle up between two of the blocks and bear its weight on them in such a fashion that the blocks tilted and presented a sloping surface. On this support it perched itself with only its tail immersed. Here it would rest for long periods of time, now and again submerging presumably because of the drying effects of the air. It looked very much like the normal performance of a *Periophthalmus*. This is shown in Plate I, Fig. 1. Such behavior went on for six days until the experiment was

discontinued.¹ One is forced to wonder about the origin of habits in fishes in which they voluntarily leave the water, for certainly *Lebistes* does not come out of water under normal conditions.

Some of the Microcyprini voluntarily leave the water even when there is no immediate suffocation, as anyone familiar with *Rivulus* can attest. These fish may be sometimes found flipping their way along in damp jungles, Breder (1927), or sometimes buried in the damp débris of the jungle floor. Their method of emergence and subsequent behavior is entirely different from that of *Lebistes* and apparently there is no connection between the two.

The second case involves a species of bottom fish, *Achirus lineatus* (Linnaeus). One such specimen, 46 mm. standard length, kept in a small aquarium at the Florida Field Laboratory of the New York Aquarium, was noticed performing in an unusual manner when, because of the death of some tank mates, the aquarium became foul. It would swim up to the surface and there flutter its long dorsal and anal in such a manner as to impel backwards the water above it, while in the meantime it would cup its body in such a fashion as to be fairly dish-shaped. By this action it cleared its upper concave surface of water and rested floating on the surface film by virtue of the water displaced. It is shown floating in this manner in Plate I, Fig. 2. This means of flotation was not entirely perfect, and it was forced intermittently to keep up the activity to prevent itself from sinking. By this performance, however, it apparently was able to take advantage of the greater concentration of oxygen at the surface in a manner similar to that of some of the Microcyprini with their flattened heads and upturned snouts. This fish finally succumbed after several days so it cannot be said whether its method was poor or merely

¹ Physical data on experiment (Nov. 6, 1933) Temp. 25.5° C.; Vol. H₂O 1488cc.; Surface area 3.5 C²; Free CO₂ 0.44 mM. For this experiment a mason jar was used as an aquarium. In another experiment fish died at a concentration of 0.46 mM. CO₂.

inadequate to the circumstances of this particular aquarium.

The only reference that we have been able to find with a bearing on this item is in Beebe & Tee-Van (1928). They report that this species performed in the following manner in Port-au-Prince Bay, Haiti. "On several nights I caught young soles of this species, near the surface, at our submerged light. They swam slowly along and when at the surface elevated the encircling ring of vertical fins, and depressed the body, and in this cupped shape floated with no apparent movement of fins or body. The tips of all the rays could be seen breaking the surface film, but I could see no difference in the level of the enclosed water and that outside. These specimens measured from 17.5 to 25 mm." Their fish were only about half as large as the present and were certainly under no suffocating influence where taken. It is thus evident that there is a background for this behavior in the activity of the smaller sizes. Apparently it is normally given up before the size of our specimen is reached. The present behavior then might be considered as a return to more juvenile activity on the incidence of adverse circumstances.

At the Field Laboratory many were kept under conditions far from ideal, but the present case is the only one which displayed this habit. Although submerged night lights were used continually they failed to attract this species. Most of our specimens were considerably larger than those of Beebe & Tee-Van.

The two cases mentioned are the only examples known to the writer who, because of circumstances, has had unusual opportunity both in the field and at home for a long period to note such items of behavior. How many *Lebistes* have been handled in that time would be hard to estimate but one item of behavior in this as well as related poeciliids stands out prominently. These fishes, when in pools with gently sloping edges, feed freely in very shallow water but are notably careful to avoid being "stranded." Consequently it must be assumed that the individual herewith discussed overcame this tendency in response to the greater pressure of suffocation.

During this same period several hundred achirids of various species and under varying conditions have never shown any disposition to the floating habit herein described.

Surely here is a waiting field of investigation in fish behavior, touching perhaps on the farthest reaches of the mental life of fishes. Such questions arise as to how instinctive are such acts and how widespread in an individual species.

REFERENCES.

- BEEBE, W. & TEE-VAN, J.
1928. The Fishes of Port-au-Prince Bay, Haiti, with a summary of the known species of marine fish of the Island of Haiti and Santo Domingo. *Zoologica*, 10 (1): 1-279.
- BREDER, C. M., JR.
1927. The Fishes of the Rio Chucunaque Drainage, Eastern Panama. *Bull. Amer. Mus. Nat. Hist.*, 57 (3): 97-176.

EXPLANATION OF THE PLATE.

PLATE I.

Fig. 1. *Lebistes reticulatus* resting out of water after the manner of a *Periophthalmus*.

Fig. 2. *Achirus lineatus* floating on the surface film of water depleted in oxygen.